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B-1 Oxygen Analyzer Operational Tests

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PROJECT: 94-P-102
TITLE: B-1 Oxygen Analyzer Operational Tests

ABSTRACT

In January 1990, the B-1 System Program Office and AFMC's Productivity, Reliability and Maintenance (PRAM) Office requested AFPTEF's assistance on testing a replacement oxygen analyzer.

B-1 aircraft have an onboard generator which supplies oxygen for the crew. Field maintenance uses a current oxygen equipment tolerance. The existing oxygen analyzer currently exhibits high failure rates, an inability to measure flow, and requires complex mathematical calculations to determine readings. The Program and PRAM office contracted with Aeronautical Systems Center's Fabrication Facility at Wright-Patterson to develop a replacement that would be more user friendly for maintenance personnel.

AFPTEF used its equipment to determine if the analyzer complies with military test transportation, handling and operational specification for lightweight equipment.

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INTRODUCTION

In January 1990, the B-1 Systems Program Office (ASD/B1L, later known as ASC/YDII) and AFMC's Productivity, Reliability and Maintenance (PRAM) office requested the Air Force Packaging Technology and Engineering Facility (AFPTEF), formerly known as AFPEA, perform operational testing on a replacement B-1 oxygen analyzer.

B-1 aircraft have an onboard generator which supplies oxygen for the crew. Field maintenance uses the oxygen analyzer to determine if the generator's operation is within equipment tolerance. The existing oxygen analyzer currently exhibits high failure rates, an inability to measure flow, and requires complex mathematical calculations to determine readings. The newly developed oxygen analyzer is designed to correct these problems and be more user friendly. The contract to manufacture six of these analyzers was awarded to the 4950th ABW/AMDE, later known as ASC/AMDE.

PURPOSE

The newly developed oxygen analyzer must be capable of accurately measuring air flow and percent oxygen to verify operation of the B-1's oxygen generating system. The new analyzers are expected to be fielded at the depots and all forward B-1 base maintenance operations. Currently B-1 aircraft are based primarily at locations which exhibit both temperature and humidity extremes. Therefore, the test plan required evaluation of the analyzer at these extremes.

TEST HISTORY

The B-1 SPO and PRAM's letter requested AFPTEF perform the tests listed in Chart 1.

TEST SPECIMENS

To perform the testing, three oxygen analyzers were used. The first analyzer suffered major irreversible damage in the Loose Cargo Bounce Test. The second analyzer was used in all the remaining testing. The third analyzer was used as a control during the Battery Voltage Drainage Test. ASC/AMDE submitted all test specimens to PMEL for calibration prior to testing.

TEST OUTLINE

<u>Test Site.</u> All testing was conducted by the Materials Engineering Branch of AFPTEF (AFMC LSO/LOPM) at Building 70, Area C, 5215 Thurlow Street, Wright-Patterson AFB, OH 45433-5540.

Test Plan. Tests were initiated as required in Test Plan #1. After the immediate failure experienced during the Loose Cargo Bounce Test, at ASC/YDII's direction, Test Plan #2 was developed. Additional testing was included in the test plan upon oral and written agreement with all parties involved.

CHART 1

TEST	SPECIFICATION AND PARAGRAPH	NON-OPERATING OPERATING
Temperature / Humidity	MIL-T-28800 paragraph 4.5.5.1.1	Non: -51 to 71 C (-60 to 160 F) Operating: -40 to 54 C (-40 to 130 F)
Altitude	MIL-T-28800 paragraph 4.5.5.2	Non-operating: 15,000 feet Operating: 6,000 feet
Sinusoidal Vibration	MIL-T-28800 paragraph 4.5.5.3.1	Non-operational
Loose Cargo Bounce	MIL-T-28800 paragraph 4.5.5.3.3	Non-operational
Functional Shock	MIL-STD-810 Method 516 Procedure I	Non-operational
Transit Drop	MIL-T-28800 paragraph 4.5.5.4.2	Non-operational
Bench Handling	MIL-T-28800 paragraph 4.5.5.4.3	Non-operational
Salt Atmosphere	MIL-T-28800 paragraph 4.5.6.2.2	Non-operational
Blowing Rain	MIL-STD-810 Method 506 Procedure I	Non-operational
Dimensions and Weight	MIL-T-28800 paragraph 4.5.7.3	Non-operational
Mechanical Stability	MIL-T-28800 paragraph 4.5.7.4	Non-operational

TESTING SEQUENCE

Test Plan #1

Test Sequence #1 - Loose Cargo Bounce Test. The test was performed with the oxygen analyzer on its top. Test was to be performed on the top, bottom and each side of the test specimen. The test followed requirements of MIL-T-28800 paragraph 4.5.5.3.3.

The following test equipment was used in running this test:

EQUIPMENT	MANUFACTURER	MODEL	SERIAL NUMBER	CALIBRATION EXPIRATION
Vibration Table	L.A.B	5000-96B	56801	N/A

RESULTS: With completion of the vibration test on its top; while rotating the analyzer to another position, an unexpected noise was heard from inside the test specimen. SPO and ASC/AMDE personnel were immediately notified. Opening the analyzer, with all relevant personnel present, severe damage was noted. Screws holding the platform and transformer in place loosened, creating the damage inside the analyzer. Internal damage included a transformer tethered by its electrical wires (photo 1) and at least two circuit boards constructed in a platform directly above the transformer. In addition, the barometric compensation circuit board (photos 2 and 3) and other plumbing and electrical connections were either loose or severed. Damage assessment of the oxygen analyzer and the flow meter by ASC/AMDE was not possible, due to the severe damage found inside the analyzer. Exterior damage included gouging to the cover (photo 4). After the test was completed a small metal object was found imbedded in the vibration table, which was not observed prior to initiating the test.

Test Plan #2

Test Sequence #1 - Temperature/Humidity (T/H). Tests continued using the approved revised test plan after receiving another operating and PMEL calibrated oxygen analyzer. As the initial test progressed, trends were observed and additional tests were requested to determine source of deviation. In all test readings, the bottle flow meter reading is taken downstream of the test analyzer meter.
The test followed requirements of MIL-T-28800, paragraph 4.5.5.1.1.

The following test equipment was used in running this test:

EQUIPMENT	**MANUFACTURER**	**MODEL**	**SERIAL NUMBER**	**CALIBRATION EXPIRATION**
Temp/altitude Chamber	Tenney Engineering	64ST	11,830	25 Mar 95
Digital Manometer	Yokogawa	26555 22	82DJ6009	11 Jun 93
Flow Meter	Sierra Engineering	821-S1-M-2	17117	11 Mar 95

RESULTS: The complete results of these T/H tests are found in Appendix 3, with additional testing results found in Appendixes 3, 4 and 5. The static pressure readings were all within compliance of the equipment's SOW for tolerances.

Test Sequence #2 - Bench Handling Test. The test was performed on the L.A.B. Vibration Table following the requirements of MIL-T-28800, paragraph 4.5.5.4.3 at ambient temperature.

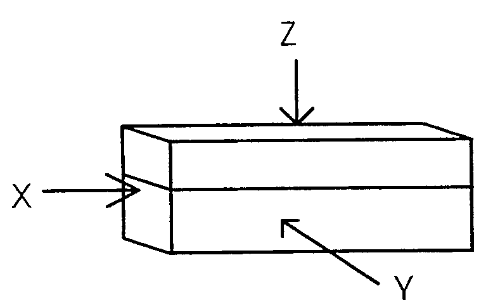
EQUIPMENT	MANUFACTURER	MODEL	SERIAL NUMBER	CALIBRATION EXPIRATION
Vibration Table	L.A.B	5000-96B	56801	N/A
Digital Manometer	Yokogawa	26555 22	82DJ6009	11 Jun 93
Flow Meter	Sierra Engineering	821-S1-M-2	17117	11 Mar 95
Volt Meter	Fluke Manufacturing	87	54360912	N/A

RESULTS: Results of these Bench Handling tests are found in Appendix 6. The results show consistent readings. All flow rates and pressures were within the tolerances required in the SOW and the test procedure. The oxygen percentage was exactly the same as prior to performing the test, but both outside of tolerance.

Test Sequence #3 - Sinusoidal Vibration Test (Modified). The test was conducted following MIL-T-28800 paragraph 4.5.5.3.1. The test modification, with the approval of the ASC/AMDE and SPO, involved performing the dwell for seven minutes per axis instead of the fifteen minutes per axis required in the specification.

EQUIPMENT	MANUFACTURER	MODEL	SERIAL NUMBER	CALIBRATION EXPIRATION
Digital Manometer	Yokogawa	26555 22	82DJ6009	11 Jun 93
Flow Meter	Sierra Engineering	821-S1-M-2	17117	11 Mar 95
Volt Meter	Fluke Manufacturing	87	54360912	N/A
Vibration Control	Data Physics Corp.	DP540	Version 1.22 7 channel, DWL	N/A
Vibration Machine	L.A.B.	41012432	89003	N/A
Vibration Controller	L.A.B.	8830	88307	N/A
Low Pass Signal Filter	Krohn-Hite	3343	1943	N/A
Table Accelerometer	Endevco	2233E	VE52	01 Nov 94
Table Charge Amplifier	Endevco	2740BT	FW26	08 Feb 95

RESULTS: The results show consistent readings. All flow rates and pressure readings were within the tolerances required in the SOW and the test procedure. In the long side (y-axis) and the vertical (z) axis the readings of the percentage oxygen were within tolerance limits, but very close to the upper tolerance. The short side (x-axis) percent oxygen readings were just outside the upper acceptable tolerance limit.



Test Sequence #4 - Battery Voltage Drain Test. It was observed, during the temperature/humidity and vibration tests, that the more frequently the battery is charged, the quicker the voltage seems to drain. After all the required tests were performed, the SPO supplied a third oxygen analyzer to be used as a control for a voltage drain test. Both analyzers were charged over a weekend and a test run to determine the time required to illuminate the "low charge light". The manufacturer fixed the "low charge light" to activate at 11.8 volts due to analyzer internal components requirements. The results of the test are charted in Appendixes 9-11.

EQUIPMENT	**MANUFACTURER**	**SERIAL NUMBER**	**CALIBRATION EXPIRATION**
Test Analyzer	ASC/AMDE	AO76557	23 Jan 96
Control Analyzer	ASC/AMDE	AO76560	22 Feb 96
Data Acquisition	System w/Data Translations Board	DT2801A	

RESULTS: The test analyzer battery voltage started at a lower initial charge; and quickly drained to lower than the minimum 11.8 volts within one hour. The control analyzer retained a higher voltage and decreased to 11.89 volts when the test was terminated 8 hours later; however the "low battery light" was illuminated at that time.

CONCLUSION

After reviewing the test data, including the additional investigations, the analyzer tested does not comply with the equipment's SOW stated tolerance requirements.

The reason for the analyzer measurement deviations was not determined. Additional tests for some of the temperature or humidity variables were inconclusive. All but one result showed the bottle flow analyzer reading higher than the test analyzer; even though it is physically downstream from the test analyzer. This raises questions about calibration of both flow meters.

The battery voltage test in Appendixes 9-11 shows that the battery quickly loses voltage to 12 volts when started. The analyzer's "low battery" light illuminates at about 11.8 volts. It took about sixty minutes to run the voltage down to illuminate the light. ASC/AMDE requires the test analyzer to be on for at least 15 minutes prior to testing. This will

severely limit the number of complete tests run prior to recharging the analyzer. The cause of this lower voltage charge may be a result of damage from the bench handling, temperature/humidity or vibration test or be a characteristic of the battery.

APPENDIX 1

31 Aug 94

DETAILED TEST PROCEDURES

FOR

B-1B OXYGEN ANALYZER

1. **LOOSE CARGO BOUNCE; MIL-T-28800D; PARA 4.5.5.3.3**

Step 1 Conduct Operational Test

- Percent Oxygen

= Per Bottle ________________ Per 02 Analyzer ________

- Pressure at Bottle ___________ Per 02 Analyzer ________
@20 PSI
- Flow Rate at Inlet ___________ Per 02 Analyzer ________

- Pressure at Bottle ___________ Per 02 Analyzer ________
@ 30 PSI
- Flow Rate at Inlet ___________ Per 02 Analyzer ________

Step 2 PASS/FAIL CRITERIA

- The unit must be within the following ranges:

-- ±1% Oxygen Concentration

-- ±2 SLM Flow Rate

-- ±1 PSI

Item Passed/Failed ____________________________

Step 3 Using suitable wooden fences constrain the test item to a horizontal movement of no more than 2 inches in any direction.

Step 4 The test item, as secured in its transit case, shall be placed on the vibration table within the constraints of step 2 above. The test item will not be operated during vibration.

Step 5 The vibration table shall be operated in the synchronous mode with the shifts in phase. (In this mode any point on the bed of the vibration table will move in a circular path in a vertical plane perpendicular to the axis of the amplitude and 284 revolutions per minute (rpm) ±2 rpm for a total of 3 hours.

Step 6 At the end of each 0.5 hour period, turn the test item to rest on a different face, so that at the end of the 3-hour period the test item will have rested on each of its six faces (top, bottom, sides, and ends).

Step 7 At the end of the 3-hour period, the test item shall be inspected. Minor surface abrasion shall not be cause for failure.

Step 8 Conduct Operational Test

- Percent Oxygen

= Per Bottle ________________ Per O2 analyzer __________

- Pressure at Bottle __________ Per O2 analyzer __________
@ 20 PSI
- Pressure at Bottle __________ Per 02 analyzer __________

- Pressure at Bottle __________ Per O2 analyzer __________
@ 30 PSI
- Pressure at Bottle __________ Per O2 analyzer __________

Step 9 PASS/FAIL CRITERIA

- The unit must be within the following ranges:
-- ±1% Oxygen Concentration
-- ±2 SLM Flow Rate
-- ±1 PSI

Item Passed/Failed ____________________________

2. **BENCH HANDLING; MIL-T-28800D; PARA 4.5.5.4.3**

Step 1 This test shall be conducted with the oxygen analyzer turned off and the lid secured as in transit/ storage. The unit shall be placed on a wooden bench top, or surface, 1.62 inches thick.

Step 2 Using one edge as a pivot, lift the opposite edge of the chassis until one of the conditions specified in (a) through (c) occurs (whichever occurs first):

a. The chassis forms an angle of 45 degrees with the horizontal bench top.

b. The lifted edge of the chassis has been raised 4 inches above the horizontal bench top.

c. The lifted edge of the chassis is just below the point of perfect balance.

Let the chassis drop back freely to the horizontal bench top. Repeat, using the other practical edges of the same horizontal face as pivot points, for a total of four drops.

Step 3 Repeat Step 2, with the test item resting on other faces until the test item has been dropped for a total of four times on each face on which the test item could be placed practicably during servicing.

Step 4 Examine the instrument for mechanical damage. Damage to any control, indicator, fuse holder, connector, or other protruding component part shall constitute failure.

Step 5 Conduct Operational Test

- Percent Oxygen

= Per Bottle ______________ Per O2 Analyzer __________

- Pressure at Bottle ___________ Per O2 Analyzer __________

@20 PSI

- Flow Rate at Inlet ___________ Per O2 Analyzer __________

- Pressure at Bottle ___________ Per O2 Analyzer __________

@30 PSI

- Flow Rate at Inlet ___________ Per O2 Analyzer __________

Step 6 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:

-- ±1% Oxygen Concentration
-- ±2 SLM Flow Rate
-- ±1 PSI

Item Passed/Failed ____

3. **SINUSOIDAL VIBRATION; MIL-T-28800D; PARA 4.5.5.3.1**

Step 1 Method of attachment. The test specimen shall be rigidly attached or strapped directly to the vibration table or to an intermediate structure which is designed to be capable of transmitting the specified magnitudes of vibration to the points of specimen attachment throughout the required test frequency range.

Step 2 During vibration, the equipment shall not be operating. The unit shall be off, and the cover shall be removed and the accelerometer placed at the CG or on the top surface (face plate).

Step 3 The frequency displacement, and time shall be as specified below. Resonance search, cycling, and dwell test times shall be continuous for the time periods specified.

Frequency increments Hz (G)	Displacement (in.) peak-to-peak	Resonance search time per increment (minutes)	Cycling time per axis (minutes)	Resonance dwell time per axis (minutes)
5 to 15	0.06	5		
16 to 25	0.04	5	15	10
26 to 55	0.02	5		

Step 4 A resonance search, cycling, and resonance dwell shall be conducted in each axis as specified in a through c:

a. Resonance search. A resonance search shall be performed at vibration levels less than those specified in Step 3 but with sufficient amplitude to excite the test item. A difference of 6 dB or more between the excitation source and the test item, or a part thereof, shall indicate the presence of a resonance. If there is an audible or visual indication of resonance or any vibration related malfunction of the equipment, an individual resonance test may be performed using the full vibratory test level and cycling time specified for the cycling test provided the resonance search time is included in the required cycling time. The test item or a subpart thereof is considered at the resonance if vibration amplitude is more than twice the amplitude of the vibration table.

b. Cycling. The test item shall be vibrated in accordance with the applicable test levels, frequency range, and times specified in Step 3. The frequency of applied vibration shall be swept over the specified range. The specified cycling time is that of an ascending plus a descending sweep and is twice the ascending sweep time.

c. Resonance dwell. The test item shall be vibrated at the most severe resonant frequency determined in the resonance search for the axis. Test levels, frequency ranges, and test times shall be in accordance with Step 3. If a change in the resonant frequency occurs during the test, its time of occurrence shall be recorded and immediately the frequency shall be adjusted to maintain the peak resonant condition. The final resonant frequency shall be recorded. If no significant resonant response is found, the equipment shall be vibrated for 10 minutes (resonance dwell) at 33 Hz.

Step 5

- Axis ____________________

- Initial Resonance Frequency ____________________

- Resonance Frequency Change to ____________________

- Final Resonance Frequency ____________________

Step 6 Conduct Operational Test

- Percent Oxygen

= Per Bottle __________ Per O2 Analyzer__________

- Pressure at Bottle __________ Per O2 Analyzer __________

@20 PSI
- Flow Rate at Inlet __________ Per O2 Analyzer __________

- Pressure at Bottle __________ Per O2 Analyzer__________

@30 PSI
- Flow Rate at Inlet __________ Per O2 Analyzer__________

Step 7 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  -- $\pm$1% Oxygen Concentration
  -- $\pm$2 SLM Flow Rate
  -- $\pm$1 PSI

Item Passed/Failed ____________________

Step 8

- Axis ____________________

- Initial Resonance Frequency ____________________

- Resonance Frequency Change to ____________________

- Final Resonance Frequency ____________________

Step 9 Conduct Operational Test

- Percent Oxygen

= Per Bottle __________ Per O2 Analyzer__________

- Pressure at Bottle __________ Per O2 Analyzer__________

@20 PSI
- Flow Rate at Inlet __________ Per O2 Analyzer__________

- Pressure at Bottle ___________ Per O2 Analyzer___________

@30 PSI

- Flow Rate at Inlet ___________ Per O2 Analyzer___________

Step 10 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  - -- ±1% Oxygen Concentration
  - -- ±2 SLM Flow Rate
  - -- ±1 PSI

Item Passed/Failed ____

Step 11

- Axis ____

- Initial Resonance Frequency ______________________________

- Resonance Frequency Change to ___________________________

- Final Resonance Frequency _______________________________

Step 12 Conduct Operational Test

- Percent Oxygen

  = Per Bottle ______________ Per O2 Analyzer___________

- Pressure at Bottle ___________ Per O2 Analyzer___________

@20 PSI

- Flow Rate at Inlet ___________ Per O2 Analyzer___________

- Pressure at Bottle ___________ Per O2 Analyzer___________

@30 PSI

- Flow Rate at Inlet ___________ Per O2 Analyzer___________

Step 13 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  - -- ±1% Oxygen Concentration
  - -- ±2 SLM Flow Rate
  - -- ±1 PSI

Item Passed/Failed ____

4. WATER PENETRATION, MIL-STD-810; METHOD 506; PROCEDURE 1

Step 1 The test unit shall be turned off, and the lid secured as in transit/storage. The test unit shall be placed in the rain chamber, in its normal operating position. Set the rainfall rate at 5 in/hr.

Step 2 Initiate the wind at 40 miles per hour and maintain for 30 minutes.

Step 3 Rotate the test item to expose to the rain source to any other side of the test item that could be exposed to blown rain in its deployment cycle.

Step 4 Repeat steps 1 through 3 until all six sides have been exposed to blown rain.

Step 5 Examine the test item in the test chamber, if possible; otherwise, remove the test item from the test facility and conduct a visual inspection. If a noticeable amount of free water has penetrated the test item, judgment must be used before operation of the test item. It may be necessary to empty water from the test item to prevent a safety hazard. Measure the volume of water.

Is any water inside the test unit? ________________

Amount of water inside the test unit ______________

Step 6 Conduct Operational Test

- Percent Oxygen

= Per Bottle ______________ Per O2 Analyzer ________

- Pressure at Bottle __________ Per O2 Analyzer ________

@20 PSI

- Pressure at Bottle __________ Per O2 Analyzer ________

- Pressure at Bottle __________ Per O2 Analyzer ________

@30 PSI

- Pressure at Bottle __________ Per O2 Analyzer ________

Step 7 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:

  - $\pm$1% Oxygen Concentration
  - $\pm$2 SLM Flow Rate
  - $\pm$1 PSI

Item Passed/Failed __________________________

5. **SALT FOG; ASTM B117-90**

Step 1 The test unit shall not be cleaned prior to testing. The test chamber shall be placed on the floor of the salt fog chamber.

Step 2 The salt solution shall be prepared in accordance with paragraph 7.1 of ASTM B117. The salt solution shall have the proper pH value per paragraph 7.2 of ASTM B117.

Step 3 The temperature of the salt fog chamber shall be in accordance with paragraph 9.2 of ASTM B117.

Date __________ Time _____________ Temperature ______

Date __________ Time _____________ Temperature ______

Date __________ Time _____________ Temperature ______

Date __________ Time _____________ Temperature ______

Step 4 The atomization and quantity of fog shall be in accordance with paragraph 9.2 of ASTM B117.

Measurement start time:
Date __________ Time __________

Measurement end time:
Date __________ Time ___________
pH Level __________ Sample Number _________

pH Level __________ Sample Number _________

pH Level __________ Sample Number _________

pH Level __________ Sample Number _________

Sample Locations:

Step 5 The salt fog test shall run for 48 hours.
Step 6 Let the test unit air dry for 48 hours at room temperature.
Step 7 Clean the test unit by spraying running water on it. Followed by air drying with forced air, compressed air.
Step 8 Examine the test unit for corrosion. This should be an external and internal examination.

Result of examination: ___________________________________
____

Step 9 Conduct Operational Test

- Percent Oxygen

= Per Bottle ____________ Per O2 Analyzer ______

- Pressure at Bottle _________ Per O2 Analyzer _____

@20 PSI
- Pressure at Bottle _________ Per O2 Analyzer _____

- Pressure at Bottle ____________ Per O2 Analyzer____________

@30 PSI

- Flow Rate at Inlet ____________ Per O2 Analyzer____________

Step 10 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  - -- $\pm$1% Oxygen Concentration
  - -- $\pm$2 SLM Flow Rate
  - -- $\pm$1 PSI

Item Passed/Failed ____

6. ALTITUDE; MIL-T-28800D; PARA 4.5.5.2

NOTE: This is a modified MIL-T-28800D; paragraph 4.5.5.4, per ASC/SDCE to meet program needs.

Step 1 Place the test unit in the altitude chamber, connect the gas supply and gas outlet instrumentation. The lid is off the test unit and the test unit will be placed so the engineer can read the readout displays with the door closed. Measure the ambient temperature. _________°F/°C maintain this temperature for the entire test. Turn on the test unit.

Step 2 Decrease the chamber pressure to an altitude of 5,000 feet, at a rate not exceeding 2,000 fpm. Maintain this temperature for 1 hour prior to proceeding to step 3.

Step 3 Conduct Operational Test

- Percent Oxygen

= Per Bottle _______________ Per O2 Analyzer _______________

- Pressure at Bottle ________ Per O2 Analyzer _______________

@20 PSI

- Flow Rate at Inlet ________ Per O2 Analyzer _______________

- Pressure at Bottle __________ Per O2 Analyzer ____________

@ 30PSI

- Flow Rate at Inlet __________ Per O2 Analyzer ____________

Step 4 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  - -- $\pm$1% Oxygen Concentration
  - -- $\pm$2 SLM Flow Rate
  - -- $\pm$1 PSI

Item Passed/Failed ____

Step 5 Return to ambient conditions. Turn off the test unit. Disconnect the gas supply and gas outlet instrumentation. Close the test unit and secure the lid as in transit/storage.

Step 6 Decrease the chamber pressure to an altitude of 15,000 feet, at a rate not exceeding 2,000 fpm. Maintain this pressure for 1 hour.

Step 7 Return to ambient conditions.

Step 8 Conduct Operational Test

- Percent Oxygen

  = Per Bottle ______________ Per O2 Analyzer ______________

- Pressure at Bottle _______ Per O2 Analyzer ______________

@20 PSI
- Flow Rate at Inlet _______ Per O2 Analyzer ______________

- Pressure at Bottle ________ Per O2 Analyzer ____________

@ 30PSI
- Flow Rate at Inlet ________ Per O2 Analyzer ____________

Step 9 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  -- $\pm$1% Oxygen Concentration
  -- $\pm$2 SLM Flow Rate
  -- $\pm$1 PSI

Item Passed/Failed ____

3. TEMPERATURE/HUMIDITY CYCLES; MIL-T-28800D; PARA 4.5.5.1.1. THROUGH 4.5.5.1.1.4.

NOTE: This is a modified MIL-T-28800D; paragraph 4.5.5.1.1 through 4.5.5.1.1.4, per ASC/YDII to meet program needs.

Note: The soak times in this test start when the temperature reaches its correct value. The RH will slowly reach its correct value.

Step 1 Place the test item in the test chamber. With the test item non operational reduce the chamber temperature until -40°C is reached. Maintain the temperature within $\pm$2°C for 24 hours.

Step 2 With the test item non operational, increase the chamber temperature until +71°C is reached. Maintain the temperature within $\pm$2°C for 24 hours.

Step 3 With the test item non operational, decrease the chamber temperature until 25°C ±2°C is reached. Maintain the temperature for 4 hours minimum.

Step 4 Conduct Operational Test

- Percent Oxygen

= Per Bottle ______________ Per O2 Analyzer ______________

- Pressure at Bottle _______ Per O2 Analyzer ______________

@20 PSI

- Flow Rate at Inlet _______ Per O2 Analyzer ______________

- Pressure at Bottle _________ Per O2 Analyzer ____________

@ 30PSI

- Flow Rate at Inlet _________ Per O2 Analyzer ____________

Step 5 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  - -- ±1% Oxygen Concentration
  - -- ±2 SLM Flow Rate
  - -- ±1 PSI

Item Passed/Failed ____

Step 6 With the test item non operational, increase the chamber temperature until 40°C ±2°C is reached. Maintain this temperature and 25 ±5 percent RH for 8 hours minimum.

Step 7 With the test item non operational decrease the chamber temperature to 25°C to ±2°C. Maintain this temperature and attempt to maintain 25 ±5 percent RH for 4 hours minimum.

Step 8 With the test item non operational, decrease the chamber temperature to 10°C ±2°C. Maintain this temperature and attempt to maintain 25 ±5 percent RH for 4 hours minimum.

Step 9 With the test item non operational, decrease the chamber temperature to 0°C ±2°C. Maintain the temperature for 4 hours minimum. The RH need not be controlled below 10°C.

Step 10 With the test item non operational, decrease the chamber temperature to -10°C ±2°C. Maintain the temperature for 4 hours minimum.

Step 11 With the test item non operational, increase the chamber temperature to 40°C ±2°C. Maintain this temperature and 25 ±5 percent RH for 4 hours minimum.

Step 12 Conduct Operational Test

- Percent Oxygen

  = Per Bottle ________________ Per O2 Analyzer ______________

- Pressure at Bottle _________ Per O2 Analyzer ______________

@20 PSI

- Flow Rate at Inlet _________ Per O2 Analyzer ______________

- Pressure at Bottle __________ Per O2 Analyzer ____________

@ 30PSI

- Flow Rate at Inlet __________ Per O2 Analyzer ____________

<u>Step 13</u> PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  - -- $\pm$1% Oxygen Concentration
  - -- $\pm$2 SLM Flow Rate
  - -- $\pm$1 PSI

Item Passed/Failed ____

<u>Step 14</u> With the test item non operational, increase the chamber temperature to 50°C $\pm$2°C. Maintain this temperature and 25 $\pm$5 percent RH for 4 hours minimum.

<u>Step 15</u> With the test item non operational, increase the chamber temperature to 55°C $\pm$2°C. Maintain this temperature and 25 $\pm$5 percent RH for 4 hours minimum.

<u>Step 16</u> With the test item non operational, decrease the chamber temperature to 25°C $\pm$2°C. Maintain this temperature and attempt to maintain 25 $\pm$5 percent RH for 4 hours minimum.

<u>Step 17</u> With the test item non operational, decrease the chamber temperature to 10°C $\pm$2°C. Maintain this temperature and attempt to maintain 45 $\pm$5 percent RH for 4 hours minimum.

<u>Step 18</u> With the test item non operational, increase the chamber temperature to 40°C $\pm$2°C. Maintain this temperature and 45 $\pm$5 percent RH for 4 hours minimum.

<u>Step 19</u> Conduct Operational Test

- Percent Oxygen

  = Per Bottle _______________ Per O2 Analyzer ______________

- Pressure at Bottle __________ Per O2 Analyzer ____________

@ 20PSI

- Flow Rate at Inlet __________ Per O2 Analyzer ____________

- Pressure at Bottle ________ Per O2 Analyzer ______________

@ 30PSI

- Flow Rate at Inlet ________ Per O2 Analyzer ______________

Step 20 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  -- $\pm$1% Oxygen Concentration
  -- $\pm$2 SLM Flow Rate
  -- $\pm$1 PSI

Item Passed/Failed ______________________________

Step 21 With the test item non operational, increase the chamber temperature to 50°C $\pm$2°C. Maintain this temperature and 45 $\pm$5 percent RH for 4 hours minimum.

Step 22 With the test item non operational, increase the chamber temperature to 55°C $\pm$2°C. Maintain this temperature and 45 $\pm$5 percent RH for 4 hours minimum.

Step 23 With the test item non operational, decrease the chamber temperature to 25°C $\pm$2°C. Maintain this temperature and 45 $\pm$5 percent RH for 4 hours minimum.

Step 24 With the test item non operational, decrease the chamber temperature to 10°C $\pm$2°C. Maintain this temperature and attempt to maintain 75 $\pm$5 percent RH for 4 hours minimum.

Step 25 Conduct Operational Test

- Percent Oxygen

  = Per Bottle ______________ Per O2 Analyzer ____________

- Pressure at Bottle __________ Per O2 Analyzer ____________

@ 20PSI

- Flow Rate at Inlet __________ Per O2 Analyzer ____________
- Pressure at Bottle _________ Per O2 Analyzer ____________

@ 30PSI

- Flow Rate at Inlet _________ Per O2 Analyzer ____________

Step 26 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  -- $\pm$1% Oxygen Concentration
  -- $\pm$2 SLM Flow Rate
  -- $\pm$1 PSI

Item Passed/Failed ______________________________

Step 27 With the test item non operational, increase the chamber temperature to 40°C $\pm$2°C. Maintain this temperature and 75 $\pm$5 percent RH for 4 hours minimum.

Step 28 With the test item non operational, increase the chamber temperature to 50°C $\pm$2°C. Maintain this temperature and 75 $\pm$5 percent RH for 4 hours minimum.

Step 29 With the test item non operational, increase the chamber temperature to 55°C ±2°C. Maintain this temperature and 75 ±5 percent RH for 4 hours minimum.

Step 30 With the test item non operational, decrease the chamber temperature to 25°C ±2°C. Maintain this temperature and 75 ±5 percent RH for 4 hours minimum.

Step 31 With the test item non operational, decrease the chamber temperature to 10°C ±2°C. Maintain this temperature and attempt to maintain 95 ±5 percent RH for 4 hours minimum.

Step 32 Conduct Operational Test

- Percent Oxygen

  = Per Bottle ____________ Per O2 Analyzer ____________

- Pressure at Bottle ________ Per O2 Analyzer ____________

@ 20PSI
- Flow Rate at Inlet ________ Per O2 Analyzer ____________

- Pressure at Bottle ________ Per O2 Analyzer ____________

@ 30PSI
- Flow Rate at Inlet ________ Per O2 Analyzer ____________

Step 33 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:

  -- ±1% Oxygen Concentration
  -- ±2 SLM Flow Rate
  -- ±1 PSI

Item Passed/Failed ______________________________

Step 34 With the test item non operational, increase the chamber temperature to 40°C ±2°C. Maintain this temperature and 95 ±5 percent RH for 4 hours minimum.

Step 35 With the test item non operational, increase the chamber temperature to 50°C ±2°C. Maintain this temperature and 95 ±5 percent RH for 4 hours minimum.

Step 36 With the test item non operational, increase the chamber temperature to 55°C ±2°C. Maintain this temperature and 95 ±5 percent RH for 4 hours minimum.

Step 37 With the test item non operational, decrease the chamber temperature to 25°C ±2°C. Maintain this temperature and 95 ±5 percent RH for 4 hours minimum.

Step 38 Conduct Operational Test

- Percent Oxygen

  = Per Bottle ______________ Per O2 Analyzer ____________

- Pressure at Bottle _________ Per O2 Analyzer ___________

@ 20PSI

- Flow Rate at Inlet _________ Per O2 Analyzer ___________

- Pressure at Bottle ________ Per O2 Analyzer ____________

@ 30 PSI

- Flow Rate at Inlet ________ Per O2 Analyzer ____________

Step 39 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:

  -- ±1% Oxygen Concentration
  -- ±2 SLM Flow Rate
  -- ±1 PSI

Item Passed/Failed ____

Step 40 Inspect the equipment to detect evidence of physical degradation. Visible corrosion is permissible if the test item operated satisfactorily in Steps 38 and 39.

APPENDIX 2

DETAILED TEST PROCEDURES

30 Dec 94

FOR

B-1B OXYGEN ANALYZER

1. **BENCH HANDLING**; MIL-T-28800D; PARA 4.5.5.4.3

<u>Step 1</u> This test shall be conducted with the oxygen analyzer turned off and the lid secured as in transit/storage. The unit shall be placed on a wooden bench top, or surface, 1.62 inches thick.

<u>Step 2</u> Using one edge as a pivot, lift the opposite edge of the chassis until one of the conditions specified in (a) through (c) occurs (whichever occurs first):

a. The chassis forms an angle of 45 degrees with the horizontal bench top.

** b. The lifted edge of the chassis has been raised 4 in. above the horizontal bench top.

c. The lifted edge of the chassis is just below the point of perfect balance.

Let the chassis drop back freely to the horizontal bench top. Repeat, using the other practical edges of the same horizontal face as pivot points, for a total of four drops.

<u>Step 3</u> Repeat Step 2, with the test item resting on other faces until the test item has been dropped for a total of four times on each face on which the test item could be placed practicably during servicing.

<u>Step 4</u> Examine the instrument for mechanical damage. Damage to any control, indicator, fuseholder, connector, or other protruding component part shall constitute failure.

<u>Step 5</u> Conduct Operational Test

- Percent Oxygen

= Per Bottle ____________ Per O2 Analyzer __________

- Pressure at Bottle __________ Per O2 Analyzer __________

@20 PSI

- Flow Rate at Inlet __________ Per O2 Analyzer __________

- Pressure at Bottle __________ Per O2 Analyzer __________

@30 PSI

- Flow Rate at Inlet __________ Per O2 Analyzer __________

Step 6 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  - -- ±1% Oxygen Concentration
  - -- ±2 SLM Flow Rate
  - -- ±1 PSI

Item Passed/Failed ______________________________

2. **SINUSOIDAL VIBRATION**; MIL-T-28800D; PARA 4.5.5.3.1

Step 1 Method of attachment. The test specimen shall be rigidly attached or strapped directly to the vibration table or to an intermediate structure which is designed to be capable of transmitting the specified magnitudes of vibration to the points of specimen attachment throughout the required test frequency range.

Step 2 During vibration, the equipment shall not be operating. The unit shall be off, and the cover shall be removed and the accelerometer placed at the CG or on the top surface (face plate).

Step 3 The frequency displacement, and time shall be as specified below. Resonance search, cycling, and dwell test times shall be continuous for the time periods specified.

Frequency increments Hz (G)	Displacement (in.) peak-to-peak	Resonance search time per increment (minutes)	Cycling time per axis (minutes)	Resonance dwell time per axis (minutes)
5 to 15	0.06	5		
16 to 25	0.04	5	15	10
26 to 55	0.02	5		

Step 4 A resonance search, cycling, and resonance dwell shall be conducted in each axis as specified in a through c:

a. Resonance search. A resonance search shall be performed at vibration levels less than those specified in Step 3 but with sufficient amplitude to excite the test item. A difference of 6 dB or more between the excitation source and the test item, or a part thereof, shall indicate the presence of a resonance. If there is an audible or visual indication of resonance or any vibration related malfunction of the equipment, an individual resonance test may be performed using the full vibratory test level and cycling time specified for the cycling test provided the resonance search time is included in the required cycling time. The test item or a subpart thereof is

considered at the resonance if vibration amplitude is more than twice the amplitude of the vibration table.

b. Cycling. The test item shall be vibrated in accordance with the applicable test levels, frequency range, and times specified in Step 3. The frequency of applied vibration shall be swept over the specified range. The specified cycling time is that of an ascending plus a descending sweep and is twice the ascending sweep time.

c. Resonance dwell. The test item shall be vibrated at the most severe resonant frequency determined in the resonance search for the axis. Test levels, frequency ranges, and test times shall be in accordance with Step 3. If a change in the resonant frequency occurs during the test, its time of occurrence shall be recorded and immediately the frequency shall be adjusted to maintain the peak resonant condition. The final resonant frequency shall be recorded. If no significant resonant response is found, the equipment shall be vibrated for 10 minutes (resonance dwell) at 33 Hz.

Step 5

- Axis ______________________________

- Initial Resonance Frequency ______________________________

- Resonance Frequency Change to ______________________________

- Final Resonance Frequency ______________________________

Step 6 Conduct Operational Test

- Percent Oxygen

= Per Bottle ______________ Per O2 Analyzer__________

@20 PSI
- Pressure at Bottle ___________ Per O2 Analyzer __________
- Flow Rate at Inlet ___________ Per O2 Analyzer __________

@30 PSI
- Pressure at Bottle ___________ Per O2 Analyzer__________
- Flow Rate at Inlet ___________ Per O2 Analyzer__________

Step 7 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
-- ±1% Oxygen Concentration
-- ±2 SLM Flow Rate
-- ±1 PSI

Item Passed/Failed ______________________________

Step 8

- Axis ____

- Initial Resonance Frequency ____________________________

- Resonance Frequency Change to __________________________

- Final Resonance Frequency ______________________________

Step 9 Conduct Operational Test

- Percent Oxygen

= Per Bottle ______________ Per O2 Analyzer__________

- Pressure at Bottle ___________ Per O2 Analyzer__________

@20 PSI

- Flow Rate at Inlet ___________ Per O2 Analyzer__________

- Pressure at Bottle ___________ Per O2 Analyzer__________

@30 PSI

- Flow Rate at Inlet ___________ Per O2 Analyzer__________

Step 10 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  - -- $\pm$1% Oxygen Concentration
  - -- $\pm$2 SLM Flow Rate
  - -- $\pm$1 PSI

Item Passed/Failed ______________________________________

Step 11

- Axis ____

- Initial Resonance Frequency ____________________________

- Resonance Frequency Change to __________________________

- Final Resonance Frequency ______________________________

Step 12 Conduct Operational Test

- Percent Oxygen

= Per Bottle ______________ Per O2 Analyzer__________

- Pressure at Bottle ___________ Per O2 Analyzer__________

@20 PSI

- Flow Rate at Inlet ___________ Per O2 Analyzer__________

- Pressure at Bottle ___________ Per O2 Analyzer___________

@30 PSI
- Flow Rate at Inlet ___________ Per O2 Analyzer___________

Step 13 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  -- ±1% Oxygen Concentration
  -- ±2 SLM Flow Rate
  -- ±1 PSI

Item Passed/Failed ______________________________________

3. **TEMPERATURE/HUMIDITY CYCLES**; MIL-T-28800D; PARA 4.5.5.1.1. THROUGH 4.5.5.1.1.4.

NOTE: This is a modified MIL-T-28800D; paragraph 4.5.5.1.1 through 4.5.5.1.1.4, per ASC/YDII to meet program needs.

Note: The soak times in this test start when the temperature reaches its correct value. The RH will slowly reach its correct value.

Step 1 Place the test item in the test chamber. With the test item nonoperating, reduce the chamber temperature until -40°C is reached. Maintain the temperature within ±2°C for 24 hours.

Step 2 With the test item nonoperating, increase the chamber temperature until +71°C is reached. Maintain the temperature within ±2°C for 24 hours.

Step 3 With the test item nonoperating, decrease the chamber temperature until 25°C ±2°C is reached. Maintain the temperature for 4 hours minimum.

Step 4 Conduct Operational Test

- Percent Oxygen

  = Per Bottle _____________ Per O2 Analyzer _____________

- Pressure at Bottle _______ Per O2 Analyzer _____________

@20 PSI
- Flow Rate at Inlet _______ Per O2 Analyzer _____________

- Pressure at Bottle _________ Per O2 Analyzer ___________

@ 30PSI
- Flow Rate at Inlet _________ Per O2 Analyzer ___________

Step 5 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  -- $\pm1\%$ Oxygen Concentration
  -- ±2 SLM Flow Rate
  -- ±1 PSI

Item Passed/Failed ______________________________

Step 6 With the test item nonoperating, increase the chamber temperature until 40°C $\pm$2°C is reached. Maintain this temperature and 25 $\pm$5 percent RH for 8 hours minimum.

Step 7 With the test item nonoperating decrease the chamber temperature to 25°C to $\pm$2°C. Maintain this temperature and attempt to maintain 25 $\pm$5 percent RH for 4 hours minimum.

Step 8 With the test item nonoperating, decrease the chamber temperature to 10°C $\pm$2°C. Maintain this temperature and attempt to maintain 25 $\pm$5 percent RH for 4 hours minimum.

Step 9 With the test item nonoperating, decrease the chamber temperature to 0°C $\pm$2°C. Maintain the temperature for 4 hours minimum. The RH need not be controlled below 10°C.

Step 10 With the test item nonoperating, decrease the chamber temperature to -10°C $\pm$2°C. Maintain the temperature for 4 hours minimum.

Step 11 With the test item nonoperating, increase the chamber temperature to 40°C $\pm$2°C. Maintain this temperature and 25 $\pm$5 percent RH for 4 hours minimum.

Step 12 Conduct Operational Test

- Percent Oxygen

  = Per Bottle ______________ Per O2 Analyzer ____________

- Pressure at Bottle ________ Per O2 Analyzer ____________

@20 PSI

- Flow Rate at Inlet ________ Per O2 Analyzer ____________

- Pressure at Bottle _________ Per O2 Analyzer ___________

@ 30PSI

- Flow Rate at Inlet _________ Per O2 Analyzer ___________

Step 13 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  -- $\pm1\%$ Oxygen Concentration
  -- ±2 SLM Flow Rate
  -- ±1 PSI

Item Passed/Failed ______________________________

Step 14 With the test item nonoperating, increase the chamber temperature to 50°C ±2°C. Maintain this temperature and 25 ±5 percent RH for 4 hours minimum.

Step 15 With the test item nonoperating, increase the chamber temperature to 55°C ±2°C. Maintain this temperature and 25 ±5 percent RH for 4 hours minimum.

Step 16 With the test item nonoperating, decrease the chamber temperature to 25°C ±2°C. Maintain this temperature and attempt to maintain 25 ±5 percent RH for 4 hours minimum.

Step 17 With the test item nonoperating, decrease the chamber temperature to 10°C ±2°C. Maintain this temperature and attempt to maintain 45 ±5 percent RH for 4 hours minimum.

Step 18 With the test item nonoperating, increase the chamber temperature to 40°C ±2°C. Maintain this temperature and 45 ±5 percent RH for 4 hours minimum.

Step 19 Conduct Operational Test

- Percent Oxygen

  = Per Bottle ____________ Per O2 Analyzer ____________

- Pressure at Bottle ________ Per O2 Analyzer ____________

@ 20PSI

- Flow Rate at Inlet ________ Per O2 Analyzer ____________

- Pressure at Bottle _______ Per O2 Analyzer ____________

@ 30PSI

- Flow Rate at Inlet _______ Per O2 Analyzer ____________

Step 20 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  -- ±1% Oxygen Concentration
  -- ±2 SLM Flow Rate
  -- ±1 PSI

Item Passed/Failed ____________________________________

Step 21 With the test item nonoperating, increase the chamber temperature to 50°C ±2°C. Maintain this temperature and 45 ±5 percent RH for 4 hours minimum.

Step 22 With the test item nonoperating, increase the chamber temperature to 55°C ±2°C. Maintain this temperature and 45 ±5 percent RH for 4 hours minimum.

Step 23 With the test item nonoperating, decrease the chamber temperature to 25°C ±2°C. Maintain this temperature and 45 ±5 percent RH for 4 hours minimum.

Step 24 With the test item nonoperating, decrease the chamber temperature to 10°C ±2°C. Maintain this temperature and attempt to maintain 75 ±5 percent RH for 4 hours minimum.

Step 25 Conduct Operational Test

- Percent Oxygen

= Per Bottle ______________ Per O2 Analyzer ____________

- Pressure at Bottle _________ Per O2 Analyzer ___________

@ 20PSI

- Flow Rate at Inlet _________ Per O2 Analyzer ___________
- Pressure at Bottle ________ Per O2 Analyzer ____________

@ 30PSI

- Flow Rate at Inlet ________ Per O2 Analyzer ____________

Step 26 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:
  - -- ±1% Oxygen Concentration
  - -- ±2 SLM Flow Rate
  - -- ±1 PSI

Item Passed/Failed ____

Step 27 With the test item nonoperating, increase the chamber temperature to 40°C ±2°C. Maintain this temperature and 75 ±5 percent RH for 4 hours minimum.

Step 28 With the test item nonoperating, increase the chamber temperature to 50°C ±2°C. Maintain this temperature and 75 ±5 percent RH for 4 hours minimum.

Step 29 With the test item nonoperating, increase the chamber temperature to 55°C ±2°C. Maintain this temperature and 75 ±5 percent RH for 4 hours minimum.

Step 30 With the test item nonoperating, decrease the chamber temperature to 25°C ±2°C. Maintain this temperature and 75 ±5 percent RH for 4 hours minimum.

Step 31 With the test item nonoperating, decrease the chamber temperature to 10°C ±2°C. Maintain this temperature and attempt to maintain 95 ±5 percent RH for 4 hours minimum.

Step 32 Conduct Operational Test

- Percent Oxygen

= Per Bottle ______________ Per O2 Analyzer ____________

- Pressure at Bottle _________ Per O2 Analyzer ___________

@ 20PSI

- Flow Rate at Inlet _________ Per O2 Analyzer ___________

- Pressure at Bottle ________ Per O2 Analyzer ____________

@ 30PSI

- Flow Rate at Inlet ________ Per O2 Analyzer ____________

Step 33 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:

  -- $\pm$1% Oxygen Concentration
  -- $\pm$2 SLM Flow Rate
  -- $\pm$1 PSI

Item Passed/Failed ____

Step 34 With the test item nonoperating, increase the chamber temperature to 40°C $\pm$2°C. Maintain this temperature and 95 $\pm$5 percent RH for 4 hours minimum.

Step 35 With the test item nonoperating, increase the chamber temperature to 50°C $\pm$2°C. Maintain this temperature and 95 $\pm$5 percent RH for 4 hours minimum.

Step 36 With the test item nonoperating, increase the chamber temperature to 55°C $\pm$2°C. Maintain this temperature and 95 $\pm$5 percent RH for 4 hours minimum.

Step 37 With the test item nonoperating, decrease the chamber temperature to 25°C $\pm$2°C. Maintain this temperature and 95 $\pm$5 percent RH for 4 hours minimum.

Step 38 Conduct Operational Test

- Percent Oxygen

  = Per Bottle ______________ Per O2 Analyzer ____________

- Pressure at Bottle _________ Per O2 Analyzer ____________

@ 20PSI

- Flow Rate at Inlet _________ Per O2 Analyzer ____________

- Pressure at Bottle ________ Per O2 Analyzer ____________

@ 30 PSI

- Flow Rate at Inlet ________ Per O2 Analyzer ____________

Step 39 PASS/FAIL CRITERIA:

- The unit must be within the following ranges:

  -- $\pm$1% Oxygen Concentration
  -- $\pm$2 SLM Flow Rate
  -- $\pm$1 PSI

Item Passed/Failed ____

Step 40 Inspect the equipment to detect evidence of physical degradation. Visible corrosion is permissible if the test item operated satisfactorily in Steps 38 and 39.

APPENDIX 3

	Initial Test 3Feb 95	Step 4 6Feb 95	Step 12 8Feb 95	Step 19 9Feb 95	Extra Step 9Feb 95	Step 24 10Feb 95	Step 32 13Feb	Step 38 14Feb 95	Extra 21Feb 95
Temperature:	40C	25C	40C	40C	25C	10C	10C	25C	40C
Humidity :	N/M	N/M	25%	45%	45%	75% **	95%	95%	25%
% Oxygen Known (57.7)	56.9±1	58.3±1	57.9±1	58.0±1	58.5±1	60.0±1	60.0±1	58.8±1	57.8
	Pass	Pass	Pass	Pass	Pass	**FAIL**	**FAIL**	**FAIL**	Pass
20 PSI									
Static @ Bottle	----*	-----*	21.3	20.3	20.2	20.2	20.2	20.2	20.1
Static @ Analyzer	----*	-----*	21.5±1	20.0±1	20.0±1	20.0± 1	20.0±1	20.2±1	19.8±1
Pass/Fail			Pass	Pass	Pass	Pass	Pass	Pass	Pass
20 PSI (corrected)									
Flow @ Bottle	17.0±1	72.4±1	54.1±1	45.1±1	65.5±1	55.8±1	57.4±1	76.0±1	47.4±1
Flow @ Analyzer	16.3±2	70.2±2	49.0±2	41.1±2	63.0±2	56.9±2	59.5±2	72.9±2	43.9±2
Pass/Fail	Pass	Pass	**FAIL**	**FAIL**	Pass	Pass	Pass	**FAIL** ***	**FAIL**
Difference LPM			(2.1)	(1.0)				(0.1)	(0.5)
30 PSI									
Static @ Bottle	-----*	------*	30.3	29.7	29.7	28.7	31.2	31.7	29.0
Static @ Analyzer	-----*	------*	30.2±1	29.4±1	29.4±1	28.6±1	31.1±1	31.6±1	28.5±1
Pass/Fail			Pass	Pass	Pass	Pass	Pass	Pass	Pass
30 PSI (corrected)									
Flow @ Bottle	-----	102±1	73.1±1	56.0±1	78.0±1	61.3±1	72.6±1	55.7±1	44.8±1
Flow @ Analyzer	-----	98.2±2	65.4±2	50.5±2	74.9±2	63.5±2	75.6±2	54.3±2	52.7±2
Pass/Fail		**FAIL**	**FAIL**	**FAIL**	**FAIL**	Pass	Pass	Pass	**FAIL**
Difference LPM		(0.8)	(4.7)	(2.5)	(0.1)				(4.9)

* Tested as dynamic not static.

** Between the time the analyzer was turned on and the initiation of testing the "low battery" light became illuminated. In a telecon (2/10) with M. Phillips, he stated that the power was less than optimal by the results should still be valid.

*** Re-test results: 36.8±1 Flow at bottle (25C at 20PSI)
35.1±1 Flow at analyzer

Extra Step on 21 Feb.: 40 degrees C and 25% RH for seven days with both the analyzer and our flowmeter experiencing this temperature and humidity condition.

N/M - not measured.

APPENDIX 4

Test Modification #3

Purpose: Test to determine if the current B-1 flow meter and/or the commercial flow meter was extremely temperature sensitive. Both flow meters' temperature specifications were within the range tested.

Test Procedure: Set up one B-1 analyzer (test) and flow meter inside the chamber with a control analyzer on the outside of the chamber. The flow initially went through the flow meter, the test analyzer then out to the control analyzer. Run initial test at ambient temperature then re-test after a minimum of six hours.

date 23 Feb 95

Initial Readings

Analyzer (Test)	-0.1 LPM	
Flow meter	0.0	Time Start 1223
Analyzer (control)	-0.3	Time Finished 1245

Test @ Room Temperature (corrected)

Analyzer (test)	40.8+2 LPM	Attendees:
Flow meter	40.8+1	Mark Phillips
Analyzer (control)	40.2+2	

Perform test after 20 hours at 40C and 25% RH.

Initial Readings

Analyzer (test)	+0.2 LPM	
Flow meter	-0.1	Time Start 0815 24 Feb
Analyzer (control)	-0.2	Time Finished 0940

Corrected Results

	@20 PSI	@30 PSI	@40 PSI
Analyzer (test)	40.6 LPM	55.2 LPM	69.6 LPM
Flow meter	42.2	56.9	71.9
Analyzer (control)	41.7	56.9	71.8

Tolerances for both analyzers ± 2 LPM
for the flow meter ± 1 LPM

Attendees:
Mark Phillips
Ray Blacklock

Results: The commercial flow meter (first measurement) inside the chamber registered nearly identical to the readings on the control analyzer (last measurement) at the flows tested. The consensus was that the analyzer's flow meter (test) is not as sensitive as the commercial flow meter. This finding can explain why in the original test

the test analyzer (up stream and in chamber) readings consistently were lower than the commercial flow meter (downstream and outside chamber). From this data, it is believed that the analyzer flow meter is not temperature sensitive; instead it is related to individual component manufacturing or PMEL calibration variances.

APPENDIX 5

Test Modification #4

Purpose: To determine if the current B-1 Oxygen analyzer is correctly operating in high humidity conditions. The initial testing revealed that at these conditions the readings were outside the required tolerances.

Test Procedure: Set-up the test B-1 analyzer inside the temperature chamber and the control analyzer outside of the chamber. This test plan roughly parallels the procedure outlined in MIL-T-28800 while simultaneously meeting the time limitations. The oxygen flow is split off going through the test analyzer inside the chamber and through the control analyzer outside the chamber.

Step 1 Conduct Initial Operational Test

Date: 23 Feb 95

Analyzer (test) 58.9 % O2 ±1 Start Time 0745
Analyzer (control) 57.8 ±1 Finish Time 0815
Known 57.7% End voltage: 11.75

Step 2

With the test item non operating, decrease the chamber temperature to -51 ±2C is reached. Maintain this temperature for a minimum of 8 hours.

Step 3

With the test item non operating, increase the chamber temperature to 71 ±2C is reached. Maintain this temperature for a minimum of 8 hours.

Step 4

With the test item non operating, increase the chamber temperature to 40 ±2C and 25 ±5% RH is reached. Maintain conditions for a minimum of four hours.

Step 5 Conduct Operational Test

Analyzer (test) 58.9 % O2 ±1 Start Time 0820
Analyzer (control) 57.8 ±1 Finish Time 0855
Known 57.7% End voltage: 11.81

Step 6

With the test item non operating, increase the chamber temperature to 40 ±2C and 45 ±5% RH is reached. Maintain conditions for a minimum of four hours.

Step 7   Conduct Operational Test

Analyzer (test)   59.0 % O2 ±1   Start Time 1330
Analyzer (control) 57.8   ±1   Finish Time 1345
Known   57.7%   End voltage: 11.89

Step 8

With the test item non operating, increase the chamber temperature to 40 ±2C and 95 ±5% RH is reached. Maintain conditions for a minimum of four hours.

Step 9   Conduct Operational Test

Analyzer (test)   58.4 % O2 ±1   Start Time 1335
Analyzer (control) 57.8   ±1   Finish Time 1400
Known   57.7%   End voltage 12.10

Four hours minimum as required in MIL-T-28800.

Test Change: The original test procedure required running the test at 10 degrees C and vary the humidity ranges, first at no humidity control and then controlled at 25% humidity. The humidity chamber's limitations and the outdoor temperature and humidity made that level of humidity control impossible.

Results: This test was initiated to determine if the analyzer is sensitive to both temperature and humidity. All readings, except the high 95% RH, were virtually the same and out of tolerance. The high humidity exception fell within the required tolerance. This runs contrary to the limited information gathered in the original test sequence. So the results of this study are inconclusive.

APPENDIX 6

Test Modification #5

Purpose: To determine if the current B-1 Oxygen analyzer is correctly reading in high temperature and various humidity conditions. This test may show if the test analyzer's oxygen sensor is more sensitive than the control analyzer, a unique equipment problem. If they both drift it may be an inherent equipment problem. The initial testing revealed that at these conditions all the readings were outside the required tolerances. This test was run after Mark Phillips, ASC/AMDE, readjusted the test analyzer's zero downward.

Test Procedure: Set-up both test B-1 analyzers inside the temperature chamber and test. This test plan roughly parallels the procedure outlined in MIL-T-28800 while simultaneously meeting the equipment's physical and the SPO's time limitations. The oxygen flow splits off into two lines outside the chamber and then goes into each analyzer.

Step 1 Conduct Initial Operational Test

Analyzer (test) 57.4 % O2 ±1
Pressure (test) 11.4 psi (operational)
Analyzer (control) 57.8 ±1
Pressure (test) 11.4 psi (operational)
Known 57.7% End voltage 11.87

Step 2

With the test item non operating, decrease the chamber temperature to -51 ±2C is reached. Maintain this temperature for a minimum of 8 hours.

Step 3

With the test item non operating, increase the chamber temperature to 71 ±2C is reached. The Sierra flow meter is to be non operational or taken out of the chamber at this temperature. Maintain this temperature for a minimum of 8 hours.

Step 4

With the test item non operating, increase the chamber temperature to 40 ±2C and 25 ±5% RH is reached. Maintain conditions for a minimum of four hours.

Step 5 Conduct Operational Test

Analyzer (test)	56.0	% O2 ±1	
Pressure (test)	19.7	psi	(operational)
Analyzer (control)	55.8	±1	
Pressure (test)	19.9	psi	(operational)
Known 57.7%			End voltage: 11.84

Step 6

With the test item non operating, increase the chamber temperature to 40 ±2C and 45 ±5% RH is reached. Maintain conditions for a minimum of four hours.

Step 7 Conduct Operational Test

Analyzer (test)	56.4	% O2 ±1	
Pressure (test)	11.2	psi	(operational)
Analyzer (control)	56.4	±1	
Pressure (test)	11.4	psi	(operational)
Known 57.7%		End voltage: 11.79	

Step 8

With the test item non operating, increase the chamber temperature to 40 ±2C and 95 ±5% RH is reached. Maintain conditions for a minimum of four hours.

Step 9 Conduct Operational Test

Analyzer (test)	56.6	% O2 ±1	
Pressure (test)	11.0	psi	(operational)
Analyzer (control)	56.5	±1	
Pressure (test)	11.3	psi	(operational)
Known 57.7%		End voltage: 12.00	

Four hours minimum as required in MIL-T-28800.

Results: Both test analyzers' readings remained consistant. The results did to not seem to drift off, in fact, they seemed to converge as humidity increased. Except for the initial test, all readings were outside of tolerance on the low side.

APPENDIX 7

Bench Handling

DATA: Prior to performing the bench handling test the analyzer was subjected to a performance check, with the following:

Percent Oxygen:

Per bottle 57.7% Per Analyzer 59.7%

Pressure @20 psi

Pressure at Bottle 22.4 Pressure at Analyzer 22.2
Flow Rate at Inlet 42.9 Flow Rate at Analyzer 42.5

Pressure @ 30 psi

Pressure at Bottle 30.1 Pressure at Analyzer 29.9
Flow Rate at Inlet 47.0 Flow Rate at Analyzer 46.5

Beginning Voltage: 12.04 v

Following the bench handling test the following results were observed:

Percent Oxygen:

Per bottle 57.7% Per Analyzer 59.7% ±1

Pressure @20 psi

Pressure at Bottle 20.8 Pressure at Analyzer 20.6 ±1
Flow Rate at Inlet 27.3 Flow Rate at Analyzer 27.1 ±2

Pressure @ 30 psi

Pressure at Bottle 30.0 Pressure at Analyzer 29.9 ±1
Flow Rate at Inlet 38.2 Flow Rate at Analyzer 38.2 ±2

Ending Voltage: 11.86 v

APPENDIX 8

Sinusoidal Vibration

DATA: The following results were observed after performing the vibration in accordance with the test plan.

Axis: Vertical (z)
Resonance Frequency: 45-48 Hz

Percent Oxygen:
Per bottle 57.7% Per Analyzer 58.5% ±1

Pressure @20 psi
Pressure at Bottle 20.3 Pressure at Analyzer 20.1 ±1
Flow Rate at Inlet 30.4 Flow Rate at Analyzer 29.9 ±2

Pressure @ 30 psi
Pressure at Bottle 28.4 Pressure at Analyzer 28.2 ±1
Flow Rate at Inlet 38.0 Flow Rate at Analyzer 37.6 ±2
Ending Voltage: 12.02 v

Axis: Long side (y)
Resonance Frequency: Not observed, so ran at 33-35 Hz

Percent Oxygen:
Per bottle 57.7% Per Analyzer 58.5% ±1

Pressure @20 psi
Pressure at Bottle 21.0 Pressure at Analyzer 20.8 ±1
Flow Rate at Inlet 29.0 Flow Rate at Analyzer 28.4 ±2

Pressure @ 30 psi
Pressure at Bottle 29.0 Pressure at Analyzer 28.8 ±1
Flow Rate at Inlet 27.9 Flow Rate at Analyzer 27.5 ±2
Ending Voltage: 11.89 v

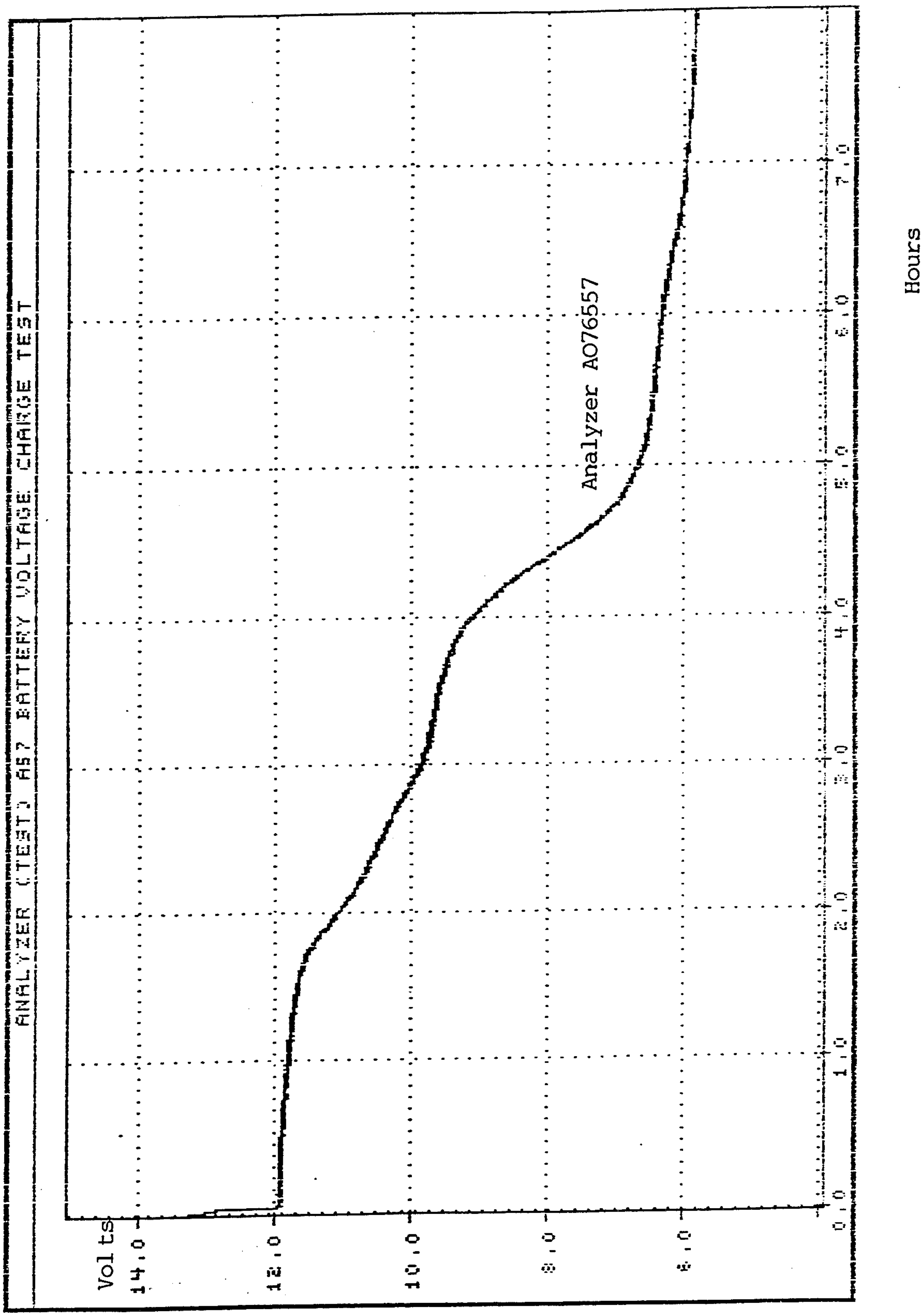
Axis: Short side (x)
Resonance Frequency: 45-47 Hz

Percent Oxygen:
Per bottle 57.7% Per Analyzer 58.8% ±1

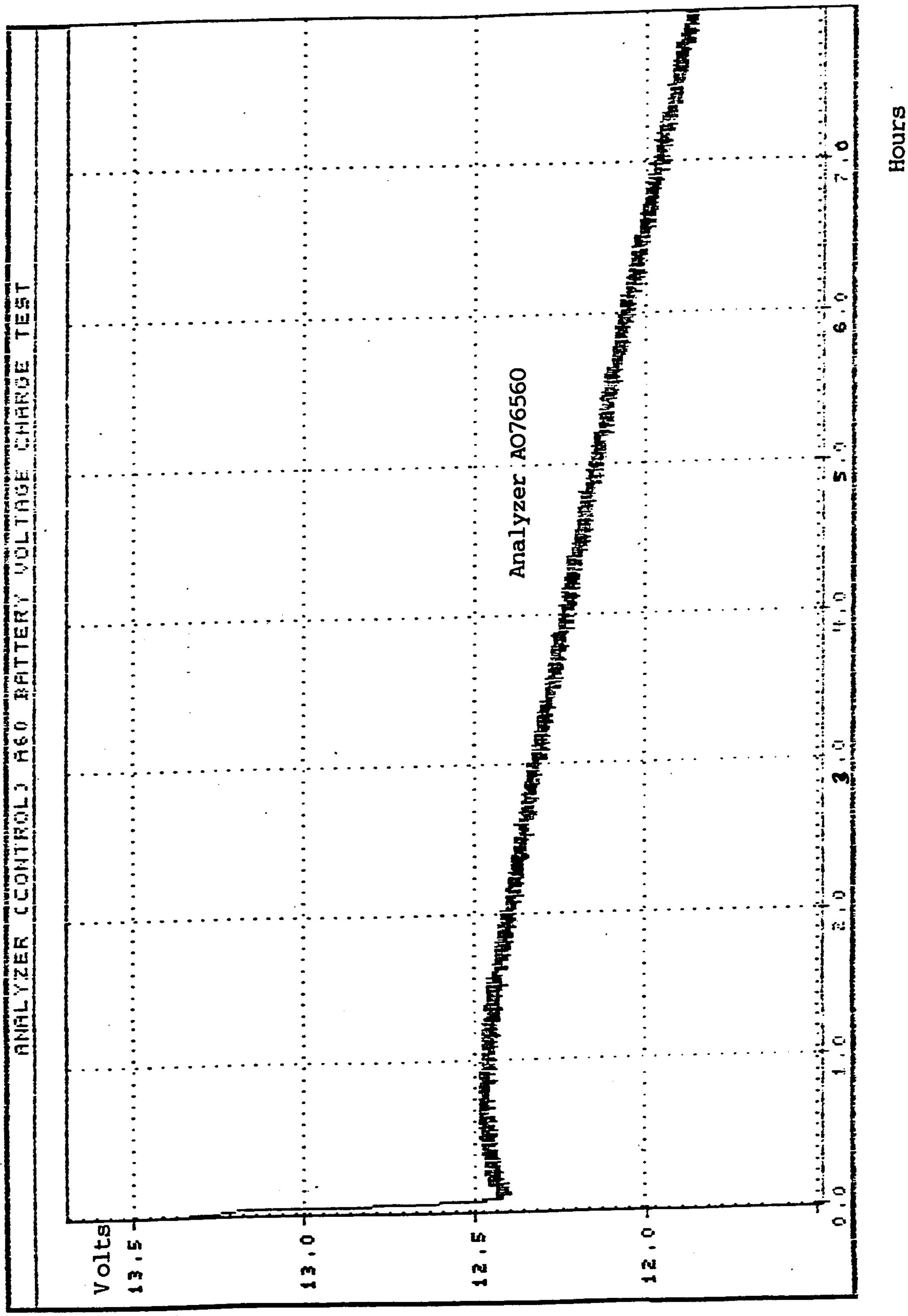
Pressure @20 psi
Pressure at Bottle 21.4 Pressure at Analyzer 21.2 ±1
Flow Rate at Inlet 19.5 Flow Rate at Analyzer 19.3 ±2

Pressure @ 30 psi
Pressure at Bottle 38.9 Pressure at Analyzer 30.7 ±1
Flow Rate at Inlet 34.4 Flow Rate at Analyzer 34.2 ±2
Ending Voltage: 11.87 v

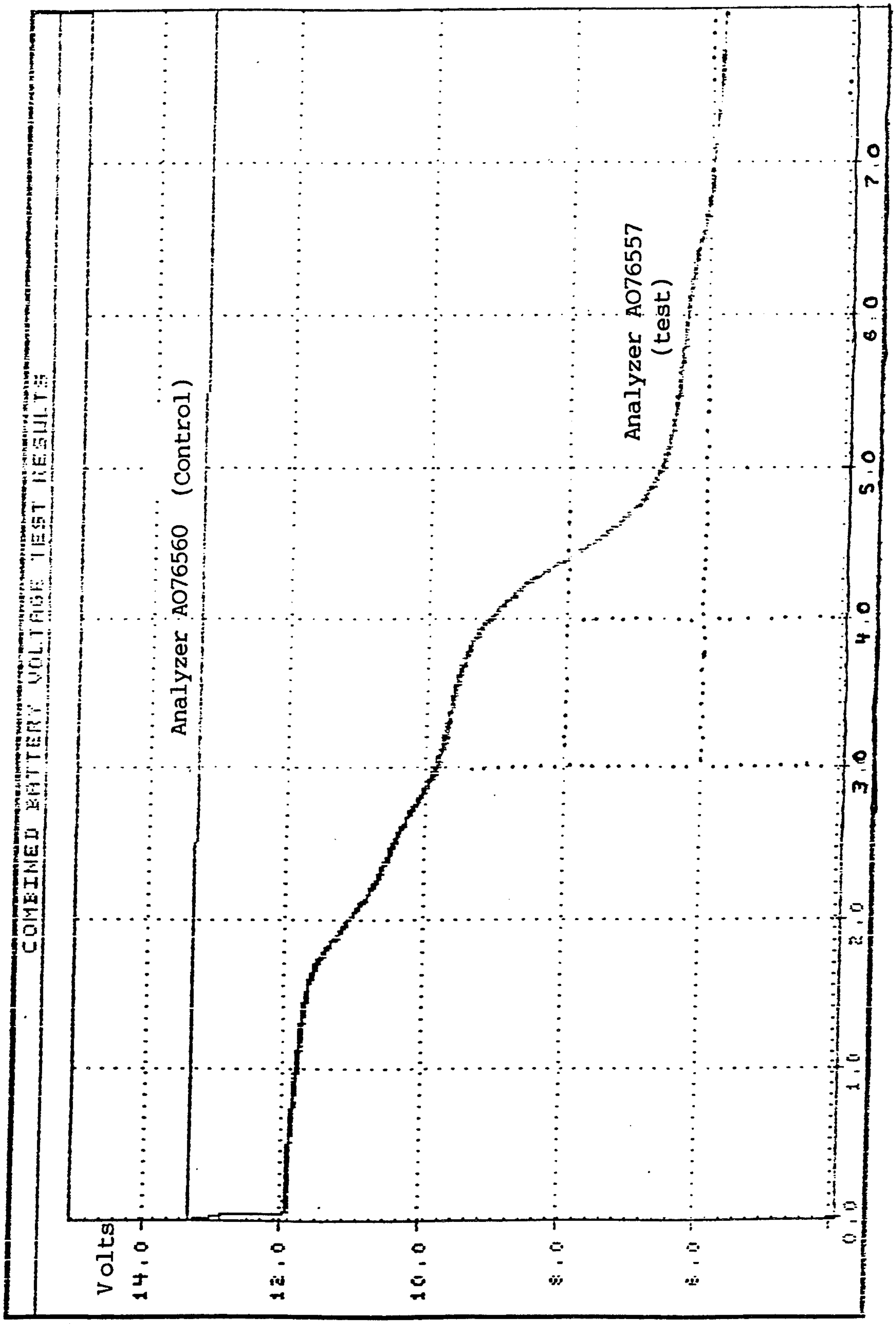
APPENDIX 9


ANALYZER (TEST) A57 BATTERY VOLTAGE CHARGE TEST
Analyzer A076557
Volts
14.0
12.0
10.0
8.0
6.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Hours

APPENDIX 10

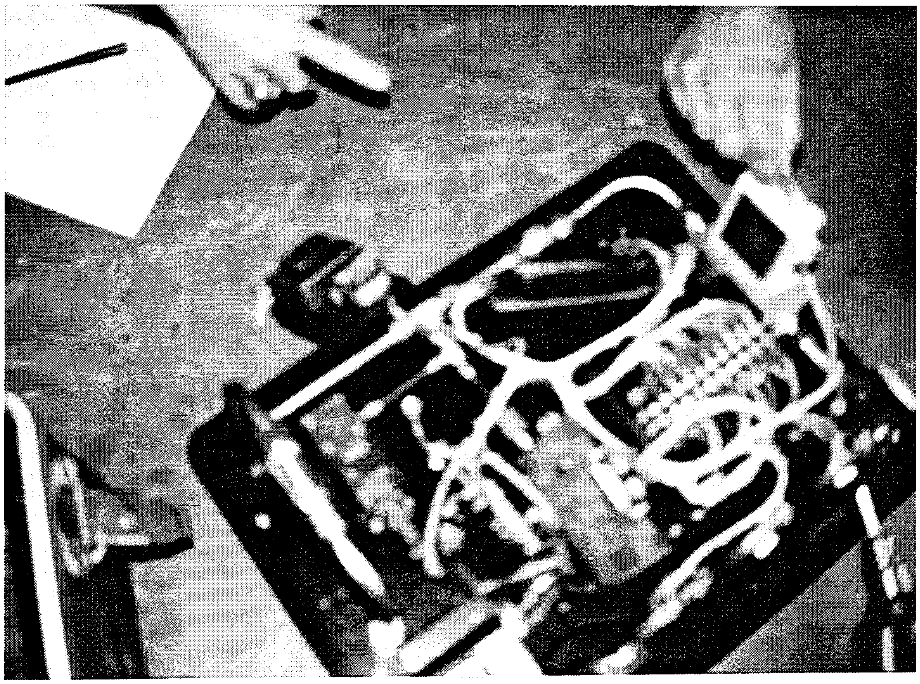

ANALYZER (CONTROL) A60 BATTERY VOLTAGE CHARGE TEST
Analyzer A076560
Volts
13.5
13.0
12.5
12.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Hours

APPENDIX 11


COMBINED BATTERY VOLTAGE TEST RESULTS
Volts
14.0
12.0
10.0
8.0
6.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Hours
Analyzer AO76560 (Control)
Analyzer AO76557
(test)

APPENDIX 12

LOOSE CARGO TEST
DAMAGE PICTURES



Phot o 1. The tethered transformer.

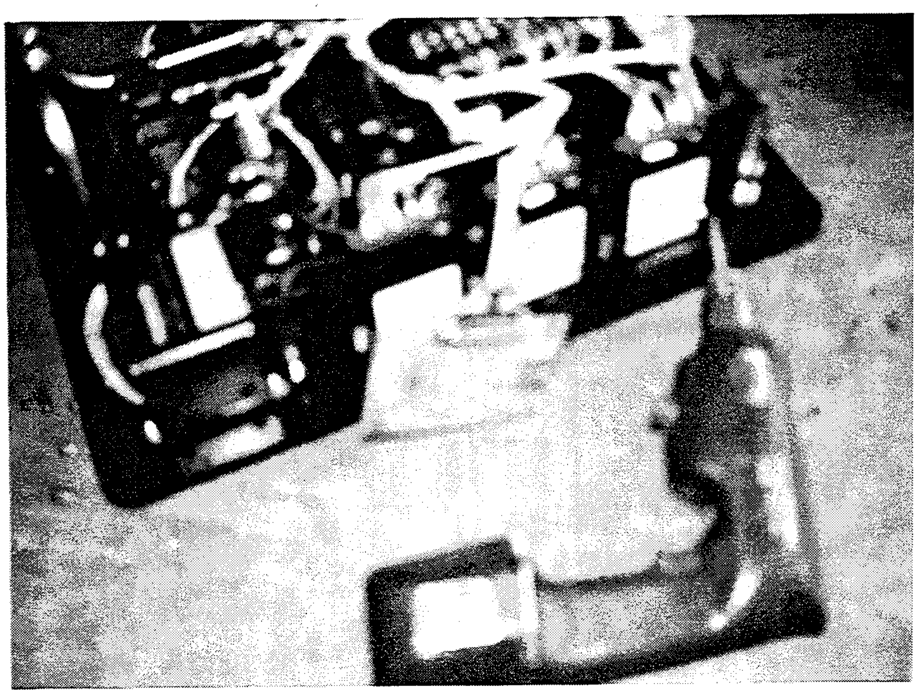


Photo 2. The loose ciruitboard.

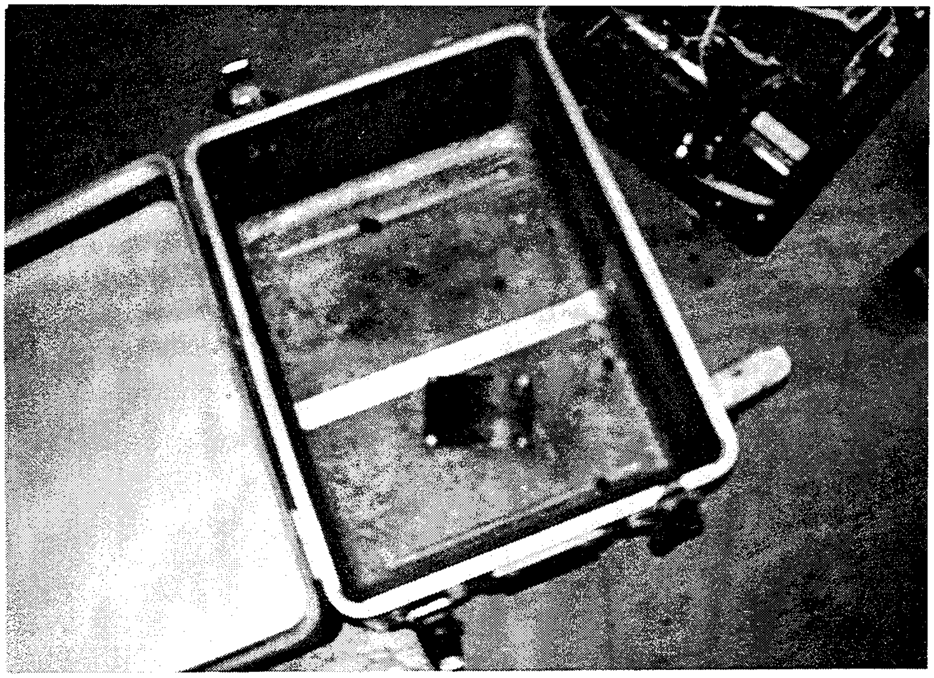


Photo 3. Loose Components.

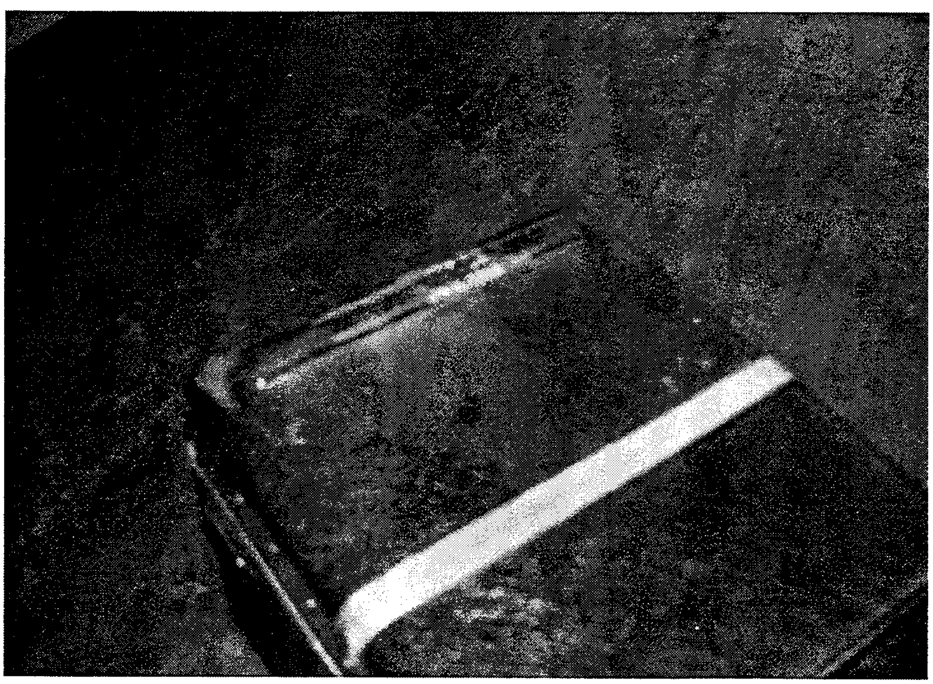


Photo 4. External Container Damage.

APPENDIX 13

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DISTRIBUTION LIST

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APPENDIX 14

STANDARD
FORM 298

REPORT DOCUMENTATION PAGE

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OMB No. 0704-0188

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Warren Assink

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Wright-Patterson AFB OH 45433-5540

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13. ABSTRACT *(Maximum 200 words)*

The B-1 program office requested AFPTEF to perform operational tests on a replacement oxygen analyzer used to determine operational status of the plane's generator. The generator supplies oxygen to the crew. The currently fielded model exhibits high failure rates, inability to measure air flow and requires highly complex mathematical calculations to determine readings. This model was developed to be much more user friendly.

AFPTEF performed standard transportation, handling and operational testing required for light weight military equipment.

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Oxygen analyzer
B-1 Bomber

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